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27–29 May 2010 • Anaheim, California, USA

Special Session: Saturday, May 29, 8:30 a.m. – 3:30 pm

Surface Ruptures, Geologic Effects, And Seismology Of The Easter Day Earthquake (April 4, 2010) In Northern Baja Mexico – Preliminary Analyses

Conveners: Tom Rockwell (SDSU) & John Fletcher (CICESE)

Other Saturday Sessions:

Managing Groundwater in the Cordillera

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Advances in Understanding Magma Petrogenesis and Eruption Dynamics at Basaltic Monogenetic Volcanoes

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Anaheim Marriot 700 West Convention Way, Anaheim, CA 92802

Register at www.geosociety.org/sectdiv/cord/2010mtg/

8:30-8:40 Opening remarks

8:40-9:00 **Strong-motion data collected in Baja California during the El Mayor-Cucapah earthquake of 4 April 2010 (Mw 7.2): preliminary results** Luis Munguia, Miguel Navarro, Tito Valdez, and Manuel Luna.

9:00-9:20 **Joint inversion of geodetic and seismic slip models for the April 04, 2010 El Mayor-Cucapah Earthquake** Shengji Wei, Anthony Sladen, Sebastien Leprince, Jean-Philippe Avouac, Eric Fielding, Risheng Chu, Mark Simons, Donald V. Helmberger, Egill Hauksson, Rowena Lohman, Rich Briggs, Ken Hudnut and Sinan Akciz.

9:20-9:40 **The surface ruptures associated with the El Mayor-Borrego earthquake sequence** John Fletcher, Tom Rockwell, Orlando Teran, Eulalia Masana, Geoff Faneros, Ken Hudnut, Javier Gonzalez, Alejandro Gonzalez, Ronald Spelz, Karl Mueller, Ling-ho Chung, Sinan Akciz, John Galetzka, Joann Stock, Kate Scharer.

9:40-10:00 **Terrestrial Lidar Scans of the El Mayor-Cucapah Earthquake Surface Rupture** Peter Gold, Austin Elliott, Michael Oskin, Andrew Herrs, Michael Taylor, Eric Cowgill.

10:00-10:20 **Slip distribution of the 2010 April 4th Baja California, Mexico Earthquake constrained using teleseismic body and surface waves and high rate GPS** Xu Zhao, Guangfu Shao, Chen Ji, Kristine Larson.

10:20-10:40 **InSAR and GPS Measurements of Crustal Deformation from the El Major Earthquake: Liquefaction and Triggered Slip** David Sandwell, M. Wei, J. Gonzales, A. Gonzales, B. Lipovski, G. Funning, Y. Fialko, R. Mellors, D. Agnew, R. Peterson and Z. Ma.

1:30-1:50 **InSAR and subpixel correlation pixel tracking measurements combined with bodywave analysis for finite fault modeling of the 2010 El Mayor-Cucapah earthquake** Eric Fielding, Shengji Wei, Sebastien Leprince, Anthony Sladen, Mark Simons, Jean-Philippe Avouac, Rowena Lohman, Rich Briggs, Ken Hudnut, Don Helmberger, Sinan Akciz.

1:50-2:10 **Preliminary Report of the Geological Effects and Damage Distribution of the April 4th, 2010 Cucapah-El Mayor Earthquake, Mexicali Valley, BC, Mexico** Francisco Suárez-Vidal, Ramón Mendoza-Borunda, Sergio Vázquez and Luis Mendoza.

2:10-2:30 **Liquefaction observations, Mexicali, Mexico – April 4, 2010 earthquake** Diane Murbach, Jim Gingery, Jorge Meneses, David Ayers, Jonathan Stewert, and Scott Brandenberg.

2:30-2:50 **Triggered Slip in Southern California as a result of the April 5, 2010 El Mayor-Cucapah Earthquake** Jerry Treiman, M.J. Rymer, K.J. Kendrick, J.J. Lienkaemper, R.J. Weldon, J.L. Hernandez, P.J. Irvine, N. Knepprath, B.P.E. Olson, and R.R. Sickler.

2:50-3:10 **Liquefaction and related ground failures in Imperial County, California, caused by the April 4, 2010 El Mayor-Cucapah earthquake** Cindy Pridmore, Scott Brandenberg, Timothy McCrink, Robert Sickler, Jonathan Stewert, and John Tinsley.

3:10-3:30 **Wrap up, discussion**

SATURDAY, 29 MAY 2010

LATE BREAKING SESSIONS
EL MAYOR-BORREGO EARTHQUAKE

SESSION NO. 1

El Mayor-Borrego Earthquake I

8:30 AM, Marriott Anaheim Hotel, Platinum 8-9

Thomas K. Rockwell and John Fletcher, Presiding

	8:30 AM	**Introductory Remarks**
1-2	8:40 AM	Munguia, Luis*; Navarro, Miguel; Valdez, Tito; Luna, Manuel: **STRONG-MOTION DATA COLLECTED IN BAJA CALIFORNIA DURING THE EL MAYOR-CUCAPAH EARTHQUAKE OF 4 APRIL 2010 (MW 7.2): PRELIMINARY RESULTS**
1-3	9:00 AM	Wei, Shengji*; Sladen, Anthony; Leprince, Sebastien; Avouac, Jean-Philippe; Fielding, Eric J.; Chu, Risheng; Simons, Mark; Helmberger, Don; Hauksson, Egill; Lohman, Rowena: **JOINT INVERSION OF GEODETIC AND SEISMIC SLIP MODELS FOR THE APRIL 04, 2010 EL MAYOR-CUCAPAH EARTHQUAKE**
1-4	9:20 AM	Fletcher, John*; Rockwell, Thomas K.; Teran, Orlando; Masana, Eulalia; Faneros, Geoff; Hudnut, Ken; Gonzalez, Javier; Gonzalez, Alejandro; Spelz, Ronald; Mueller, Karl: **THE SURFACE RUPTURES ASSOCIATED WITH THE EL MAYOR-BORREGO EARTHQUAKE SEQUENCE**
1-5	9:40 AM	Gold, Peter*; Elliott, Austin; Oskin, Michael; Herrs, Andrew J.; Taylor, Michael H.; Cowgill, Eric: **TERRESTRIAL LIDAR SCANS OF THE EL MAYOR-CUCAPAH EARTHQUAKE SURFACE RUPTURE**
1-6	10:00 AM	Xu, Zhao*; Shao, Guangfu; Ji, Chen; Larson, Kristine: **SLIP DISTRIBUTION OF THE 2010 APRIL 4th BAJA CALIFORNIA, MEXCO EARTHQUAKE CONSTRAINED USING TELESEISMIC BODY AND SURFACE WAVES AND HIGH RATE GPS**
1-7	10:20 AM	Sandwell, David T.*; Wei, M.; Gonzales, J.; Gonzales, A.; Lipovski, B.; Funning, G.; Fialko, Y.; Mellors, R.; Agnew, D.; Peterson, R.: **InSAR AND GPS MEASUREMENTS OF CRUSTAL DEFORMATION FROM THE EL MAJOR EARTHQUAKE: LIQUEFACTION AND TRIGGERED SLIP**
	10:40 AM	**Coffee and Poster Break**

SESSION NO. 2

El Mayor-Borrego Earthquake II

1:30 PM, Marriott Anaheim Hotel, Platinum 8-9

Thomas K. Rockwell and John Fletcher, Presiding

2-1	1:30 PM	Fielding, Eric J.*; Leprince, Sebastien; Wei, Shengji; Sladen, Anthony; Simons, Mark; Avouac, Jean-Philippe; Lohman, Rowena; Briggs, Rich; Hudnut, Ken; Helmberger, Don: **InSAR AND SUBPIXEL-CORRELATION PIXEL-TRACKING MEASUREMENTS OF THE 2010 EL MAYOR-CUCAPAH EARTHQUAKE**
2-2	1:50 PM	Suárez-Vidal, Francisco*; Mendoza-Borunda, Ramón; Vázquez, Sergio; Mendoza, Luis: **PRELIMINARY REPORT OF THE GEOLOGICAL EFFECTS AND DAMAGE DISTRIBUTION OF THE APRIL 4th, 2010 CUCAPAH-EL MAYOR EARTHQUAKE, MEXICALI VALLEY, BC, MEXICO**
2-3	2:10 PM	Murbach, Diane*; Gingery, Jim; Meneses, Jorge; Ayers, David; Stewart, Jonathan P.; Brandenberg, Scott: **LIQUEFACTION OBSERVATIONS MEXICALI, MEXICO – APRIL 4, 2010 EARTHQUAKE**
2-4	2:30 PM	Treiman, J.A.*; Rymer, M.J.; Kendrick, K.J.; Lienkaemper, J.J.; Weldon, R.J. II.; Hernandez, J.L.; Irvine, P.J.; Knepprath, N.; Olson, B.P.E.; Sickler, R.R.: **TRIGGERED SLIP IN SOUTHERN CALIFORNIA AS A RESULT OF THE APRIL 5, 2010 EL MAYOR-CUCAPAH EARTHQUAKE**
2-5	2:50 PM	Pridmore, Cynthia L.*; Brandenberg, Scott; McCrink, Timothy P.; Sickler, Robert; Stewart, Jonathan P.; Tinsley, John C.: **LIQUEFACTION AND RELATED GROUND FAILURES IN IMPERIAL COUNTY, CALIFORNIA, CAUSED BY THE APRIL 4, 2010 EL MAYOR-CUCAPAH EARTHQUAKE**
	3:10 PM	**Wrap up, discussion**

SESSION NO. LB1, 8:30 AM

Saturday, 29 May 2010

El Mayor-Borrego Earthquake I

Marriott Anaheim Hotel, Platinum 8-9

LB1-2 **8:40 AM** Munguia, Luis

STRONG-MOTION DATA COLLECTED IN BAJA CALIFORNIA DURING THE EL MAYOR-CUCAPAH EARTHQUAKE OF 4 APRIL 2010 (MW 7.2): PRELIMINARY RESULTS

MUNGUIA, Luis, NAVARRO, Miguel, VALDEZ, Tito, and LUNA, Manuel, División de Ciencias de la Tierra, Centro de Investigación Científica y de Educación Superior de Ensenada, B. C. Ensenada, Baja California, C. P. 22860, Mexico, lmunguia@cicese.mx

The El Mayor-Cucapah earthquake of 4 April 2010 occurred at 15:40 local time in Baja California (22:40 UTC). Since February 1892, when an earthquake of similar magnitude occurred at the northwestern end of the Laguna Salada fault, no other earthquake of this size had occurred in the area. The April 2010 earthquake had its epicenter at a point located slightly east of the zone at which the sierras El Mayor and Cucapah join together. Its effects were felt at more than 300 miles from the epicenter.

In this study, we analyze the strong motion data recorded by thirteen stations of a seismic network that is operated by CICESE in the north Baja California region. Our dataset is constituted by accelerograms produced by the main event at distances that are between 12 and 140 km from its epicenter. Six out of the thirteen triggered stations are located on the sediments of the Mexicali Valley, at less than 35 kilometers from the main shock epicenter; the other stations recorded the earthquake on granitic rocks of the peninsular ranges of Baja California.

In this paper, we present the epicenter of the main event that was determined using only the P-wave arrival times from records of the strong- and weak-motion stations that were closer to the epicenter. In the hypocenter location process, the determination of the focal depth was poorly constrained by data. However, a tendency of the location program to put the focus at a shallow depth was clearly noted. Several runs of the epicenter location program were performed for fixed values of depth. The results show that depths between 2 and 10 km produce nearly the same horizontal coordinates, but the lower time residuals are observed in association with the shallower-depth solutions.

Regarding strong motion parameters, the recorded peak ground acceleration, velocity and displacement values were by far higher at the sediment sites (12 to 35 km distance) than at the rock sites (60 to 140 km distance). On sediments, the recorded peak accelerations varied from 145 to 799 gals, while on the rock sites the peak accelerations were in the range 13 to 73 gals. The peak ground velocity and displacement values recorded on sediment sites are between 14 and 61 cm/sec and 9 and 52 cm, respectively, with the larger values observed on the horizontal components of motion.

In addition to the above strong motion characteristics, aspects of the earthquake like ground motion spectra and preliminary estimations of the seismic energy radiation and stress drop, based on the locally recorded strong motion recordings, will also be presented.

LB1-3 **9:00 AM** Wei, Shengji

JOINT INVERSION OF GEODETIC AND SEISMIC SLIP MODELS FOR THE APRIL 04, 2010 EL MAYOR-CUCAPAH EARTHQUAKE

WEI, Shengji[1], SLADEN, Anthony[1], LEPRINCE, Sebastien[1], AVOUAC, Jean-Philippe[2], FIELDING, Eric J.[1], CHU, Risheng, SIMONS, Mark[1], HELMBERGER, Don, HAUKSSON, Egill[3], and LOHMAN, Rowena, (1) Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, (2) Geological and Planetary Sciences, California Institute of Technology, 1200 E. California Blvd, MC 100-23, Pasadena, CA 91125, (3) Seismological Laboratory, California Institute of Technology, 1200 E. California Blvd., MS 252-21, Pasadena, CA 91125

We use teleseismic records together with measurements of static ground displacements at GPS stations and derived from optical and InSAR satellite images, to derive a finite source kinematic model of the April 4, 2010, the Mw7.2 El Mayor-Cucapah (Baja, California) earthquake. The sub-pixel correlation of optical SPOT 2.5 m panchromatic images indicates that the rupture broke the surface for over 55km to the northwest of the epicenter with an average of 2.5m right-lateral slip. Southeast of the epicenter, the InSAR data reveals offsets of up to a meter over even a larger length. We modeled the teleseismic waveforms using these constraints and the co-seismic displacements measured at a number of California GPS stations. The seismic records show that the earthquake released a total seismic moment of $M_0=7.9*10^{26}$ dyne*cm(Mw7.2) in the first 40 seconds of rupture. The inversion of the first 15 seconds of teleseismic body wave shows that the quake started as a normal event consistent with a mechanism of 345°/45°/-80° (strike/dip/rake) and a moment of at least Mw6.3. The earthquake then paused and continued on the main N310°E striking fault strand producing a bilateral transtensional rupture. Most of the slip to the north of the epicenter required to match the optical, InSAR and GPS observations seems to have been coseismic. By contrast, our preliminary results suggest that some significant fraction of the slip on the fault strand south of the epicenter was aseismic.

Additional co-authors on this abstract: Rich Briggs, Ken Hudnut, and Sinan Akciz.

LB1-4 **9:20 AM** Fletcher, John

THE SURFACE RUPTURES ASSOCIATED WITH THE EL MAYOR-BORREGO EARTHQUAKE SEQUENCE

FLETCHER, John[1], ROCKWELL, Thomas K.[2], TERAN, Orlando, MASANA, Eulalia[2], FANEROS, Geoff, HUDNUT, Ken, GONZALEZ, Javier, GONZALEZ, Alejandro, SPELZ, Ronald, and MUELLER, Karl[3], (1) Geology, CICESE, PO Box 434843, San DIego, CA 92143, jfletche@cicese.mx, (2) Geological Sciences, San Diego State University, 5500 Campanile Dr, San Diego, CA 92182-1020, (3) Geological Sciences, University of Colorado, Campus Box 399, 2200 Colorado Ave, Boulder, CO 80309

Surface rupture associated with the April 4, 2010 El Mayor-Borrego earthquake extends ~100 km from the northern tip of the Gulf of California to the international border and comprises two distinct geomorphologic and structural domains. The rupture is complex, with breaks along multiple fault strands, including minor re-rupture of the scarps associated with the 1892 Laguna Salada earthquake and several other older events. The southern part of the rupture consists of a zone of distributed fracturing and liquefaction that cuts across the Colorado River delta. Individual fractures vary widely in orientation and have relatively short strike lengths of the order of hundreds of meters. The zone itself may be related to faults that bound the eastern margin of the

Sierra El Mayor, but field relationships are unclear, and the zone of more intense fracturing diverges significantly from the mountain front toward the south. The northern half of the rupture propagated 55 km through an imbricate stack of east-dipping faults in the Sierra Cucapah. In the southern Sierra Cucapah, rupture extends 20 km along the Laguna Salada and Pescadores faults and reached a maximum displacement of ~ 250 cm of right-lateral strike-slip. The amount of dip slip is variable and changes polarity along strike along the Laguna Salada Fault before becoming predominantly east-down with maximum offsets of 150 cm along the Pescadores Fault. This ruptured terminates in the high elevations of the sierra and jumps nearly 10 km north in a left stepover to the Borrego fault. Additionally the northern Laguna Salada fault (1892 segment) rebroke with minor (10-30 cm) dip slip along a segment that is adjacent to the primary Borrego rupture. Maximum measured displacement along the Borrego fault in Borrego Valley was about 3.1 m of strike slip and another 2 m of down-to-the-east dip slip on a nearly vertical fault, yielding oblique slip of nearly 4 m. A low-angle detachment intersects the footwall of the central portion of the Borrego fault at a segment boundary, and rupture bifurcates with a splay that follows the trace of the detachment in a more westerly direction. Over the next 6 km to the north, rupture steps left across a 2km wide zone before finally consolidating on a fault that we have named the Paso Superior Fault, extending an additional ~10 km farther north. The Paso Superior fault is well-exposed at Highway 2, where it is clearly involves a low-angle detachment. Scarps near the fault trace accommodate dip slip, and nearly twice as much strike-slip is spread across a 100-150 m wide zone of cracking and secondary faulting to the east.

Part of the complexity of the rupture can be attributed to interaction with detachment faults that allow the rupture to expand in the near surface. This rupture illustrates the complexity that can develop when a rupture propagates through a network of high- and-low angle faults that accommodate the three-dimensional strain of transtensional plate margin shearing.

Additional co-authors on this abstract: Ling-ho Chung; Sinan Akciz (Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139); John Galetzka (Tectonics Observatory, California Institute of Technology, CA 91125); Joann Stock (Seismological Laboratory, California Institute of Technology, Pasadena, CA 91125); Kate Scharer.

LB1-5 **9:40 AM** Gold, Peter

TERRESTRIAL LIDAR SCANS OF THE EL MAYOR-CUCAPAH EARTHQUAKE SURFACE RUPTURE

GOLD, Peter[1], ELLIOTT, Austin[1], OSKIN, Michael[2], HERRS, Andrew J.[3], TAYLOR, Michael H.[3], and COWGILL, Eric[2], (1) Department of Geology, University of California Davis, 1 Shields Avenue, Davis, CA 95616, (2) W.M. Keck Center for Active Visualization in the Earth Sciences, University of California, Davis, One Shields Avenue, Davis, CA 95616, (3) Department of Geology, University of Kansas, 1475 Jayhawk Blvd, Lawrence, KS 66045

We collected ground-based lidar scans with centimeter resolution of surface rupture associated with the 4 April El Mayor-Cucapah earthquake. Two teams, using instruments from UC Davis and UNAVCO, commenced data collection twelve days after the earthquake. Four sites were scanned from multiple positions, covering approximately one kilometer of fault length. These scans preserve fine-scale fault-zone features including scarp free-faces, fault striae, landform offsets, distributed faulting and warping of the ground surface. The surveys focus on the zone of maximum slip identified along the Borrego fault, and document a range of fault localization in various substrates. These surveys represent among the first uses of lidar for rapid scientific response following an earthquake. This dataset also serves as an archive of fault slip and will form the basis for repeat surveys to record fault scarp degradation and postseismic deformation. Here we present examples of various rupture styles captured by the lidar scans. We also compare preliminary slip measurements extracted directly from the full-resolution lidar point cloud to independently collected field measurements.

LB1-6 **10:00 AM** Xu, Zhao

SLIP DISTRIBUTION OF THE 2010 APRIL 4TH BAJA CALIFORNIA, MEXCO EARTHQUAKE CONSTRAINED USING TELESEISMIC BODY AND SURFACE WAVES AND HIGH RATE GPS

XU, Zhao[1], SHAO, Guangfu[1], JI, Chen[1], and LARSON, Kristine[2], (1) Chinese Earthquake Administration, China, Institute of Crustal Studies, UCSB, (2) University of Colorado, Boulder, CO

We study the complex rupture history of the 2010 April 4 Mw 7.3 Baja California earthquake by simultaneously inverting local high rate GPS waveforms, teleseismic body and long period surface waves. The GPS displacements are included as well. We have first constructed a 1D velocity structure from the 3D SCEC CVM-H model to represent the structure of the source region and have corrected SH and surface wave propagation effects using nearby 2009 Dec 30 M5.8 foreshock. To compress the basin reverberation effects which our velocity model could not reproduce yet, all high rate GPS waveforms were lowpass filtered to less than 0.1 Hz before the inversions. Our result reveals a complex rupture process of the 2010 event. It had a weak initiation. The energetic rupture started 6 s after the initiation as a normal fault sub-event near the hypocenter and then ruptured bilaterally to both southeast and northwest directions. The rupture to the northwest is well resolved by the extensive high rate GPS waveforms. The preferred fault plane has a strike of 313^o and a dip angle of 80^o. The rupture is very heterogeneous, changing from pure strike-slip motion to oblique motion from epicenter to the northwest, consistent with surface observations. The rupture stopped sharply 50 km northwest of epicenter. The inverted peak slip is 5 m and seismic moment of this segment is $5x10^{26}$ dyne.cm. The rupture to the southeast is still under investigation. Our preliminary result suggests that this rupture extended as far as 50 km to the N133^{o}E with two large asperities. The first one is close to epicenter and the second one is 45 km southeast, with a peak slip of 4 m. Our inversion also requires a large normal motion subevent (Mw 6.9) on a separating fault plane with a lower dip angle (65^o) to match the long period surface waves. The total seismic moment is $1.2x10^{27}$ dyne.cm, with most of slip occurring 18 to 40 s after the rupture initiation.

LB1-7 **10:20 AM** Sandwell, David T.

INSAR AND GPS MEASUREMENTS OF CRUSTAL DEFORMATION FROM THE EL MAJOR EARTHQUAKE: LIQUEFACTION AND TRIGGERED SLIP

SANDWELL, David T., WEI, M., GONZALES, J., GONZALES, A., LIPOVSKI, B., FUNNING, G., FIALKO, Y., MELLORS, R., AGNEW, D., and PETERSON, R., Scripps Institution of Oceanography, UCSD, 1102 IGPP, La Jolla, CA 92093-0225, dsandwell@ucsd.edu

Our work is focused on recovering the co-seismic and postseismic deformation of the rupture using a combination of radar interferometry and GPS. Most of the surface rupture and damage occurred south of the US - Mexico Border where there are no continuously operating GPS stations and few stable monuments for measuring coseismic and postseismic deformation. Beginning on April 5 we installed four continuously operating GPS stations on the east, south, and west sides of the main rupture. In addition we began a GPS field campaign to collect post-earthquake deformation measurements on the 11 monuments within 50 km of the main rupture. The vector deformation measurements will be used to calibrate the co- and post-seismic interferograms being collected by ALOS and ENVISAT. The combined data will ultimately be used to invert for subsurface slip.

Initial InSAR results show three main features: 1) The main rupture in the Sierra Cucapah and El Major consists of at least two concentrations of right-lateral and east-side down normal faulting. Interferograms are decorrelated in the steep mountain areas where the combination of ground acceleration and steep slope produces major surface slides. 2) The southwest extension of the rupture goes beneath the agricultural area of the Colorado River Delta. This area sustained major damage. More important the ALOS interferogram reveals the boundaries of the liquefaction zone in

the agricultural areas southeast of the fault zone. This zone of liquefaction is bounded on the east by the Cerro Prieto fault and on the west by the Laguna Salada fault. The zone is 18 kilometers wide and 60 km long. Field observations show that the roads have undulations with vertical amplitudes of 20-50 cm and most of the concrete lined aqueducts are fractured. Interferograms are decorrelated over much of the area although azimuth offsets help to delineate the zone of deep slip. 3) The ENVISAT interferograms show triggered slip on several strands of the northern Cerro Prieto Fault near the border, the Superstition Hills Fault, the Imperial Fault north of Interstate 8, the Coyote Creek Fault and three sections of the San Andreas Fault. One linear deformation zone southeast of Bombay Beach is either slip on a southern strand of the San Andreas Fault or subsidence along the Lake Cahuilla shoreline. We hope to establish the style and amount of triggered slip in each case using interferograms with multiple look directions.

Also co-authored on this abstract is Z. Ma.

SESSION NO. LB2, 1:30 PM

Saturday, 29 May 2010

El Mayor-Borrego Earthquake II

Marriott Anaheim Hotel, Platinum 8-9

LB2-1 **1:30 PM** Fielding, Eric J.

INSAR AND SUBPIXEL-CORRELATION PIXEL-TRACKING MEASUREMENTS OF THE 2010 EL MAYOR-CUCAPAH EARTHQUAKE

FIELDING, Eric J.[1], LEPRINCE, Sebastien, WEI, Shengji, SLADEN, Anthony, SIMONS, Mark, AVOUAC, Jean-Philippe[2], LOHMAN, Rowena, BRIGGS, Rich, HUDNUT, Ken, and HELMBERGER, Don, (1) Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, eric.j.fielding@jpl.nasa.gov, (2) Geological and Planetary Sciences, California Institute of Technology, 1200 E. California Blvd, MC 100-23, Pasadena, CA 91125

We use interferometric analysis of synthetic aperture radar (SAR) images (InSAR) and pixel tracking by subpixel correlation of SAR and optical images to map the fault ruptures and surface deformation of the 4 April 2010 El Mayor-Cucapah earthquake (Mw 7.2) in Baja California, Mexico. The pixel-tracking measurements from SPOT 2.5 m panchromatic images and from Envisat ASAR and ALOS PALSAR images measure the large ground displacements close to the fault ruptures, with a strong discontinuity where the rupture reached the surface. The optical image subpixel correlation measures horizontal displacements in both the east-west and north-south directions and show the earthquake ruptured the Pescadores fault in the southern Sierra Cucapah and the Borrego fault in the central and northern edge of the mountain range. At the south end of the Sierra Cucapah, the fault ruptures fork into two subparallel strands with substantial slip on both visible until the agricultural area where correlation is lost and where the epicenter was located. The SAR image subpixel correlation measures horizontal deformation in the along-track (azimuth) direction of the satellite (approximately north or south) and in the radar line-of-sight (range) direction that is a combination of east-west and vertical displacements. The SAR along-track offsets, especially on the L-band ALOS images, show that there is a large amount of right-lateral slip (1-3 m) on a previously unmapped system of faults extending about 60 km to the southeast of the epicenter beneath the Colorado River Delta. The InSAR analyses of Envisat, ALOS and UAVSAR images, which use the phase of the SAR interferograms, measure the surface displacements in the same radar line-of-sight as the range pixel tracking, but with much greater precision. The combination of SAR images from different directions allows the separation of the vertical and east components of the deformation, revealing the large normal fault slip in the Sierra Cucapah (down to the east) and blocks with substantial vertical motion in the Delta (both down to the east and down to the west). The InSAR also reveals slip on many minor faults on both sides of the Sierra Cucapah and to the northwest, with displacements of cm to 10's of cm.

Also co-authored on this abstract is Sinan Akciz, Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139.

LB2-2 **1:50 PM** Suárez-Vidal, Francisco

PRELIMINARY REPORT OF THE GEOLOGICAL EFFECTS AND DAMAGE DISTRIBUTION OF THE APRIL 4TH, 2010 CUCAPAH-EL MAYOR EARTHQUAKE, MEXICALI VALLEY, BC, MEXICO

SUÁREZ-VIDAL, Francisco[1], MENDOZA-BORUNDA, Ramón[1], VÁZQUEZ, Sergio[2], and MENDOZA, Luis[2], (1) Departamento de Geología y, División de Ciencias de la Tierra, CICESE, fsuarez@cicese.mx, (2) Departamento de Sismología, División de Ciencias de la Tierra, CICESE

Twenty four hours after the Cucapah-El Mayor Earthquake occurs, the Mexicali Valley was inspected. The aim of the reconnaissance work was to obtain direct evidences of ground ruptures in the area of the epicenter as well as to document any other phenomena related to the seismic event. We found a lot of damage in the small villages (*e.g.,* Town Cucapah Mestizo, Ejido Nayarit, Ejido Zacamoto, Ejido Oaxaca) and in the agricultural areas that lie closer to the epicentral zone; this damage is associated primarily to the extensive soil liquefaction, and in second term to the fracturing of the ground. The great amount of water and sand extruded from underground due to liquefaction, inundate several of the already cited small towns. Although this geologic phenomenon took place in the entire region, it is important to note that, its effects decrease to the east of the Nuevo León-Oaxaca-Ledón boundary. On the other hand, in relation to the ground cracking and deformation because of the earthquake shaking, at the field level and in a low-fly, high-resolution aerial photographs taken by INEGI few days after the earthquake, the largest fractures in the area were observed in the agricultural fields, near the drains or irrigation channels, and some of them cutting the pave roads and dirt roads connecting the ejidos. These fractures seem to be in most of the cases purely extensional features, but it is not uncommon to find ground cracks with vertical displacements in the order of tens of centimeters. In general, the fracture network has a NNW-to-NNE orientation. In synthesis, we can say that the damage inventory derived from the April 4th earthquake includes: zones of inundation, buried zones by liquefied sand ejected, ruptures on the pave and dirt roads, cracking of the hydraulic infrastructure, tilting of power line towers, and partial or total collapse of many houses. Between 25,000 and 35,000 persons were evacuated and are waiting to see where they are going to be relocated.

LB2-3 **2:10 PM** Murbach, Diane

LIQUEFACTION OBSERVATIONS MEXICALI, MEXICO – APRIL 4, 2010 EARTHQUAKE

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The M_W 7.2 Sierra El Mayor-Cucapah Earthquake occurred in Northern Baja California, Mexico on April 4, 2010. The epicenter was positioned in the farming communities approximately 30 miles south southeast of Mexicali, Mexico on the western side of a broad flat extensional sedimentary basin known as the Mexicali Valley. A significant effect of the earthquake was widespread liquefaction. Liquefaction features were observed across the Mexicali Valley that included lateral spreading, settlement, ground fissures, sand volcanoes and flooding. Observations after the earthquake noted the presence of loose, saturated, fine sand and non-plastic silts, and a shallow ground water table contributing to the liquefaction. Liquefaction-associated effects on structures included differential settlement, bearing capacity failures and severe lateral spreading damage. Structure types affected included single-story homes to multi-story buildings, irrigation canals, bridges and roads. Impacts from liquefaction included topographic warping of the previous flat farmland and roads and severe damage to lined and unlined irrigation canals. Observations along the Rio Hardy River noted significant lateral spread damage displacements and damage along and adjacent to its banks. Sand volcanoes and sand fissures were scattered across the farm land, and around and in residential structures. The sand volcanoes were described by locals to have shot up to six feet above the ground. Six locations in the Mexicali Valley where significant liquefaction effects were observed will be presented: 1) UABC University Campus; 2) Rio Hardy River ranch; 3) Baseball field in residential area; 4) Farm land; 5) Colorado River bridges; 6) Residential homes.

LB2-4 **2:30 PM** Treiman, J.A.

TRIGGERED SLIP IN SOUTHERN CALIFORNIA AS A RESULT OF THE APRIL 5, 2010 EL MAYOR-CUCAPAH EARTHQUAKE

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The magnitude and aftershock distribution from the M_w 7.2 El Mayor-Cucapah earthquake prompted our search for the expected triggered slip on several faults over a broad area extending roughly 100 km north of the U.S.-Mexico border. We mapped right-lateral triggered slip on the San Andreas, Imperial, Coyote Creek, and Superstition Hills faults, all previously known to experience triggered slip during significant regional earthquakes. Triggered slip varied from sub-millimeter to locally in excess of 20 mm. Triggered slip (dextral) was also mapped, for the first time, on the Brawley and Wienert faults (~10 mm and <5 mm slip maxima, respectively), as well as normal displacement on the Kalin Fault within the Brawley Seismic Zone. Additionally we mapped slip on two strands of the Laguna Salada fault that extended across the border northward for at least 5.5 km; dextral slip on these faults was commonly in the 10-20 mm range but locally as great as 35 mm and vertical separation was up to 30 mm.

Notable in this event was triggered slip on northeast-trending faults within the Yuha Desert area. Minor (sub-millimeter) slip was observed along a short section of the Yuha Wells Fault, but more significant was up to 45 mm left-lateral slip on a previously unknown northeast-trending fault about 10 km southeast of the Yuha Wells Fault.

A brief search found no triggered slip on some other well-known faults in the region, including the Elsinore, Superstition Mountain, and Elmore Ranch faults. Likewise, we saw no new slip on the Rico Fault or on short faults northwest of Plaster City.

LB2-5 **2:50 PM** Pridmore, Cynthia L.

LIQUEFACTION AND RELATED GROUND FAILURES IN IMPERIAL COUNTY, CALIFORNIA, CAUSED BY THE APRIL 4, 2010 EL MAYOR-CUCAPAH EARTHQUAKE

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Representatives of GEER, the U.S. Geological Survey and the California Geological Survey surveyed liquefaction occurrences in Imperial Valley within a week of the April 4 El Mayor – Cucapah earthquake. These reconnaissance-level field investigations concentrated on easily-accessed locations along major and minor roads, canals and drains, and the New and Alamo rivers. Liquefaction occurrences were most common in the southwest portion of Imperial Valley, though a significant exception was encountered northwest of the town of Holtville.

Most road closures were associated with crossings of the New River or its tributaries, and predominantly found to be caused by liquefaction of bridge approach fills and/or the soils underlying the fills. This was the case at Worthington, Drew, and Brockman roads where they cross the New River, and at Brockman Road and possibly Lyons Road where they cross the Greeson Drain. Where Lyons Road crosses the New River, liquefaction-induced lateral spreading occurred in natural soils and road fill 100 meters east and 200 meters west of the bridge, and the bridge structure and approach fills were undamaged.

Most damage to irrigation canals appears concentrated on the Westside Main Canal, from its diversion from the All American Canal northeast to Fites Road, approximately 6 km southwest of Brawley. Liquefaction of relatively fine-grained soils was observed at the foundation of the All American Canal aqueduct over the New River. Liquefaction accompanied by lateral spreading on both sides of the Rosita Canal northwest of Holtville disrupted the canal and allowed seepage onto adjacent agricultural fields.

Other notable liquefaction-related damage includes: liquefaction and lateral displacement of the dam embankment and adjoining Drew Road at the western end of Sunbeam Lake south of Seeley; a large lateral spread into the Rice Drain No. 3 north of Evan Hewes Highway west of El Centro; liquefaction-induced slump of a levee allowed overtopping of the levee likely by seiche waves generated in Fig Lagoon; lateral spreading of the access road and sludge ponds at the Calexico Waste Water Treatment Plant. Notable sites that liquefied during the 1979 Imperial Valley earthquake did not re-liquefy on April 4th, including the Wildlife liquefaction array and the Heber Road site.